OHIO RIVER BASIN PRECIPITATION FREQUENCY PROJECT

Update of *Technical Paper No. 40, NWS HYDRO-35* and *Technical Paper No. 49*

Eighteenth Progress Report
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DISCLAIMER

The data and information presented in this report are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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1. Introduction

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for the Ohio River Basin and surrounding states. Current precipitation frequency estimates for this area are contained in *Technical Paper No. 40* "Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years" (Hershfield 1961), *NWS HYDRO-35* "Five- to 60-minute precipitation frequency for the eastern and central United States" (Frederick et al 1977) and *Technical Paper No. 49* "Two- to ten-day precipitation for return periods of 2 to 100 years in the contiguous United States" (Miller et al 1964). The new project includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The project will determine annual all-season precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1,000 years. The project will review and process all appropriate rainfall data for the project area and use accepted statistical methods. The project results will be published as a Volume of NOAA Atlas 14 on the Internet with the additional ability to download digital files.

The project will produce estimates for 13 states. Parts of nine additional bordering states are included to ensure continuity across state borders. The core and border areas, as well as daily and hourly regions now used in the analysis, are shown in Figures 1 and 2.

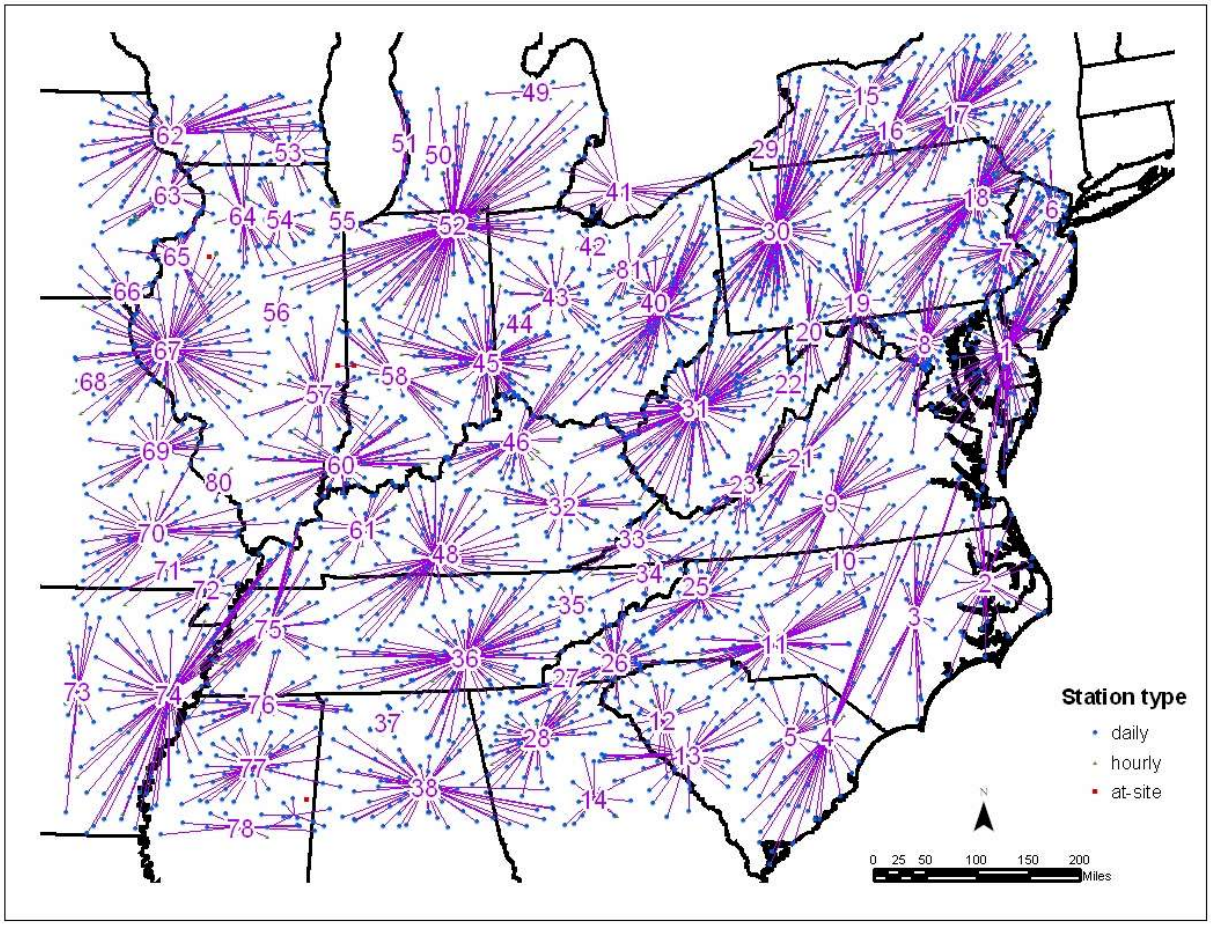


Figure 1. Ohio River Basin project area and 81 daily regional groups.

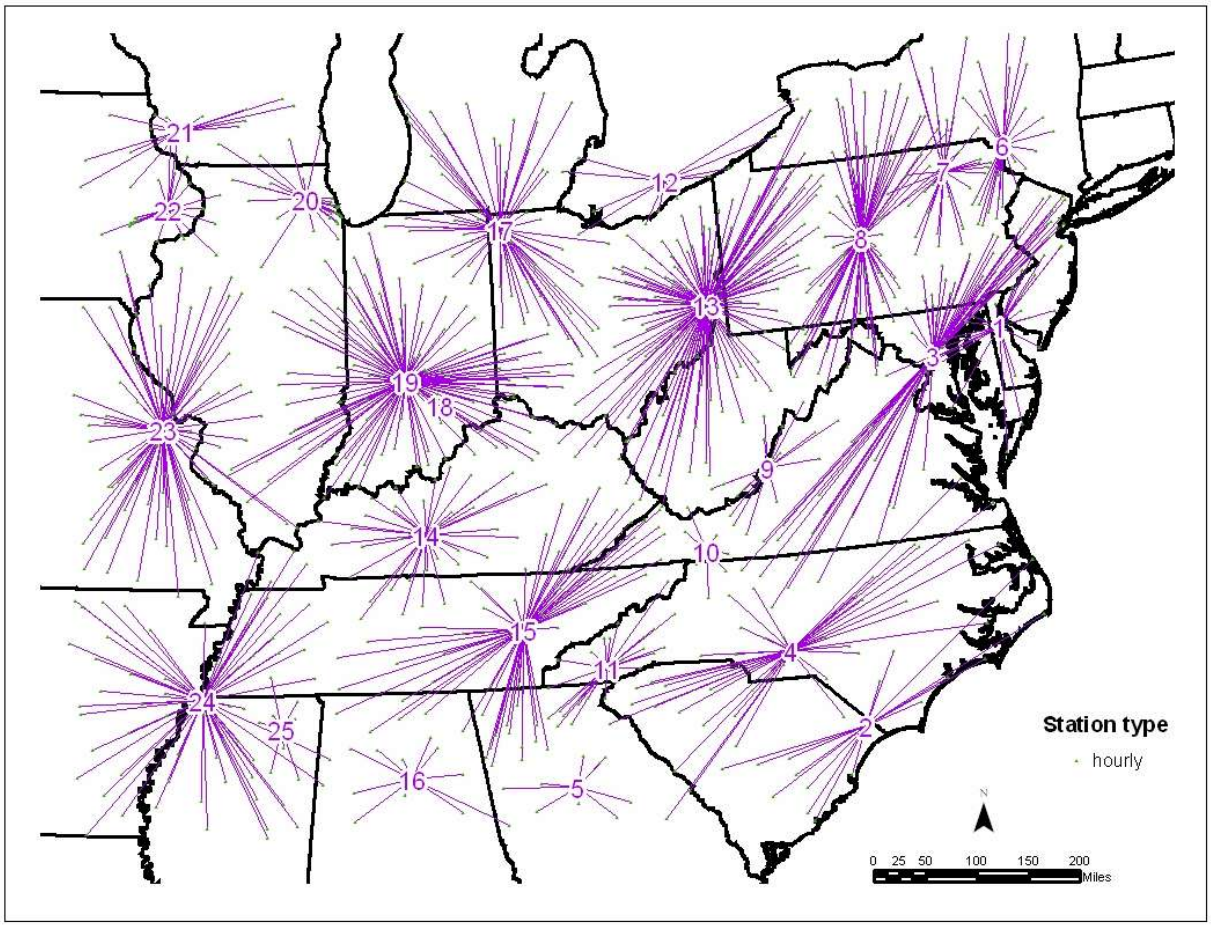


Figure 2. Ohio River Basin project area and 25 hourly regional groups.

2. Highlights

Cases where the maximum observed amount for a longer duration (i.e., 2-day through 60-day) exceeded the 1,000-year estimate were assessed for any data quality issues. Additional information is provided in Section 3.1, Data Quality Control.

To resolve remaining items from the Peer Review, additional measures have been taken to mitigate spatial bull's eyes. These measures include adjusting hourly-only stations for consistency with nearby co-located hourly/daily stations, re-regionalization, and additional spatial smoothing techniques. Additional information is provided in Section 3.2, Spatial Bull's Eyes.

Sensitivity testing verified the suitability of using the 24-hour selected distribution for longer durations. Additional information is provided in Section 3.3, L-moment Analysis.

Software was written to check for common data errors found in the accumulations of longer durations. Software was written to make hourly-only stations consistent with nearby co-located hourly/daily stations and thereby reduce bull's eyes in the hourly results. Additional information is provided in Section 3.4, Software Updates

Final mean annual maximums for all durations were delivered to SCAS at Oregon State University for spatial interpolation using PRISM technology on February 27th, 2004. Quality control of the final grids is complete. SCAS will deliver the final mean annual maximum precipitation grids to HDSC in early April. Additional information is provided in Section 3.5, Spatial Interpolation.

Temporal distributions of heavy rainfall have been posted on-line at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_temporal.html. The outline for the final documentation of NOAA Atlas 14 has been refined. Sections of the final text have been written. Additional information is provided in Section 3.6, Final Documentation.

Study areas to be used and tested in the areal reduction factor (ARF) development have been selected and all but one have been quality controlled. Three additional study areas were added. Software development to process the data and ultimately generate the ARF curves is complete. Additional information is provided in Section 3.7, Areal Reduction Factors.

3. Progress in this Reporting Period

3.1 Data Quality Control

In the real data check (RDC), longer duration (2-day through 60-day) cases where maximum observed precipitation accumulations exceeded the upper limits of the 1,000-year precipitation frequency estimates by more than 5% were investigated for data quality. In some instances, the same extreme event was an RDC issue for multiple durations. In all, at least 30 stations were found to have data errors when compared to nearby stations using NCDC Climatological Data and/or original observation forms as posted on NOAA's "Web Search Store Retrieve Display" (WSSRD) website. Incorrect values were replaced with correct values where available or set to missing. Software was developed and used to catch additional commonly observed data errors at stations (see Section 3.4 Software Updates).

3.2 Spatial Bull's Eyes

The Peer Review of the 100-year 24-hour and 100-year 60-minute maps indicated that a major concern of users is insufficient spatial smoothing that allows bull's eyes in the spatially interpolated maps. The main drivers of these spatial artifacts are:

1. A bull's eye in the mean annual maximum grids due to anomalously low (or high) values from data sampling of particularly dry or wet periods occurring in either:
    a) the PRISM mean annual precipitation grids
    b) and/or mean annual maximum values
2. A bull's eye in the quantile due to the co-located adjustments applied at hourly/daily stations that occur in different daily regions or near to hourly-only stations that were not adjusted

To address the first driver for all durations, the potential of increased spatial smoothing to mitigate bull's eyes was explored. Tests showed that increasing the spatial smoothing of the base mean annual precipitation (MAP) grids as derived by PRISM technology at the Spatial Climate Analysis Service (SCAS) at Oregon State University does mitigate some bull's eyes. The increased smoothing involves modifying the station weighting such that any station within 60 km of the target cell is assumed to be 60 km (about 15 grid cells) away and given the same weight. This results in a smoothing of all patterns less than 60 km in length. This additional smoothing was applied by SCAS to the final MAP grids for all durations.

To mitigate 60-minute bull's eyes and address the second driver, software was modified to adjust hourly quantiles according to their co-located daily station and/or according to the daily regional characteristics from the 24-hour quantile through to the 2-hour quantile. Specifically, hourly stations that are co-located with a daily station are adjusted using ratios of the 24-hour station means and ratios of the daily and hourly regional growth factors. Hourly-only stations are adjusted using an average ratio of the daily and hourly regional growth factor ratios for all co-located stations within the hourly

region. In addition, preliminary hourly maps were examined for inconsistencies between durations and data quality issues.

Finally, to mitigate 24-hour bull's eyes, stations and regions were re-assessed. Eighteen or more bull's eyes were identified and closely examined. Where appropriate, stations or groups of stations were moved from one region to another to mitigate spatial bull's eyes. Minor shifting of stations occurred in regions 2-5, 9, 10, 21, 23-25, 33, 34, 52, 54, 55, 57, 66, 67, 78, and 79.

Once the final precipitation frequency maps are derived, the effectiveness of the mitigation of the bull's eyes will be assessed. If needed, further smoothing techniques will be developed and applied to the final precipitation frequency grids.

3.3 L-moment Analysis

It has been assumed that the selected probability distribution function for the 24-hour analysis should be used for the analysis of longer durations to maintain consistency. Sensitivity testing of distributions at long durations verified that this is an appropriate assumption. The 2-day, 7-day and 30-day durations were selected to test. Regions where the best-fitting distribution, as determined by 3 separate tests, for each longer duration did not match the selected distribution from the 24-hour analysis were tested for sensitivity when using the different distributions. Regions where the best-fitting distribution would yield more conservative (i.e., higher) estimates than the selected distribution were the primary focus. If changes in the 100-year quantiles were less than 5%, then the selected distribution was considered adequate. All cases passed the sensitivity testing.

3.4 Software Updates

Software was written to check for common data errors found in the accumulations of daily values for longer durations. The software flags the following:

1. Recurring daily precipitation amounts above a user-entered threshold in a month
2. Consecutive recurring daily precipitation amounts above a user-entered threshold in a month
3. Months in which all daily amounts are zero or missing except for a daily amount that is above a user-entered threshold on one of the last 3 days

These flagged occurrences are then checked for data errors that may impact longer duration accumulations.

Software was written to make hourly-only stations consistent with nearby co-located hourly/daily stations and thereby reduce bull's eyes in the hourly results. The software adjusts hourly quantiles according to their co-located daily station and/or according to the daily regional characteristics from the 24-hour quantile through to the 2-hour quantile. See Section 3.2, Spatial Bull's Eyes, for more details.

3.5 Spatial Interpolation

On February 27, 2004 HDSC delivered the final point mean annual precipitation values (for all durations, 60-minute through 60-day) to the Spatial Climate Analysis Service (SCAS) at Oregon State University. Dr. Christopher Daly of SCAS spent several weeks spatially interpolating the point values to grids using PRISM, Parameter-elevation Regressions on Independent Slopes Model.

During this time, quality control continued. For instance, the new 1971-2000 mean annual precipitation (MAP) grid had anomalously low values at three stations causing a bull's eye effect in the mean annual maximum grids. A manual fix of these locally suppressed areas in the PRISM 1971-2000 MAP grid mitigated the problem in/around the following stations: Wateree Dam, SC; Tangier Island, VA; and Manassas, VA. Pickens 1, WV was also investigated but the high value seemed reasonable due to the topography of the area. In addition, Helton, NC was flagged due to its anomalously low mean annual maximum compared to nearby stations. However, the data looks reasonable and the terrain is varied enough in this area to warrant the differences observed. This station is marked for future inspection once the final smoothed grids are available.

Additional smoothing to mitigate spatial bull's eyes was investigated and has been applied to the base MAP grids by the Spatial Climate Analysis Service (SCAS) at Oregon State University. See Section 3.2 Spatial Bull's Eyes for more details.

On March 30th, Tye Parzybok of HDSC traveled to SCAS to evaluate final mean annual maximum grids. A careful evaluation of each duration grid was conducted. A few new localized bull's eye issues arose, but were resolved through investigation into the new 1971-2000 grid. In large part due to PRISM's coastal proximity algorithms, the coastlines looked good and spatially consistent. Across the Ohio River Basin domain, the square root of the PRISM mean annual 1971-2000 precipitation, which is the underlying predictor grid, related well to the mean annual maximum estimates. In summary, the results were very good and passed internal consistency checks requiring no further adjustments.

In early April 2004 SCAS will deliver the final grids (Table 1) to HDSC.

Table 1: Mean annual maximum grids interpolated by PRISM.

Duration
60-minute
120-minute
3-hour
6-hour
12-hour
24-hour
48-hour
4-day
7-day
10-day
20-day
30-day
45-day
60-day
14 grids total

3.6 Final Documentation

Temporal distributions of heavy rainfall for the Ohio River Basin and surrounding states have been posted on-line at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_temporal.html. The report includes information about temporal distributions designed for use with precipitation frequency estimates in NOAA Atlas 14. Documentation included there includes a description of the methodology and an interpretation of the results. Temporal distribution graphs for the 6-hour, 12-hour, 24-hour and 96-hour are provided.

The outline for the final documentation of NOAA Atlas 14 has been refined. Sections of the text, specifically the Preface, Introduction, and Methodology sections, have been written for the Semiarid Project and can easily be modified to reflect the Ohio Project.

3.7 Areal Reduction Factors

Progress continues in the development of geographically-fixed Areal-Reduction-Factor (ARF) curves for area sizes of 10 to 400 square miles. Development and testing of software from the procedure described in NOAA Technical Report NWS 24 (TR-24) is complete. A preliminary set of ARF curves for the 2-year return period for the Chicago, IL area study site has been generated (see Figure 3). They are consistent with results published in TR-24.

Three additional study areas (southeast Michigan, Albuquerque, and Seattle) have been identified and added to the list of areas used to develop the final set of ARF curves. Quality control on the Hawaiian hourly reporting data (covering the period 1960 through

2002) and additional Puerto Rico hourly reporting data (covering the period 1998 through 2002) has been performed and completed. Only the Seattle dataset remains to be quality controlled. A total of 15 study areas throughout the United States will be used in the study (see Figure 4). The "not used" study areas indicated in Figure 4 were considered but judged inadequate for the study due to poor data, limited or no metadata, or other problems. The set of ARF curves developed for each study area used will be tested for differences to determine if a single set of ARF curves can be used for the entire U.S. as is the case today or whether separate curves for different regions of the country are more appropriate.

Figure 3: Preliminary ARF curves based on test data in the Chicago area.

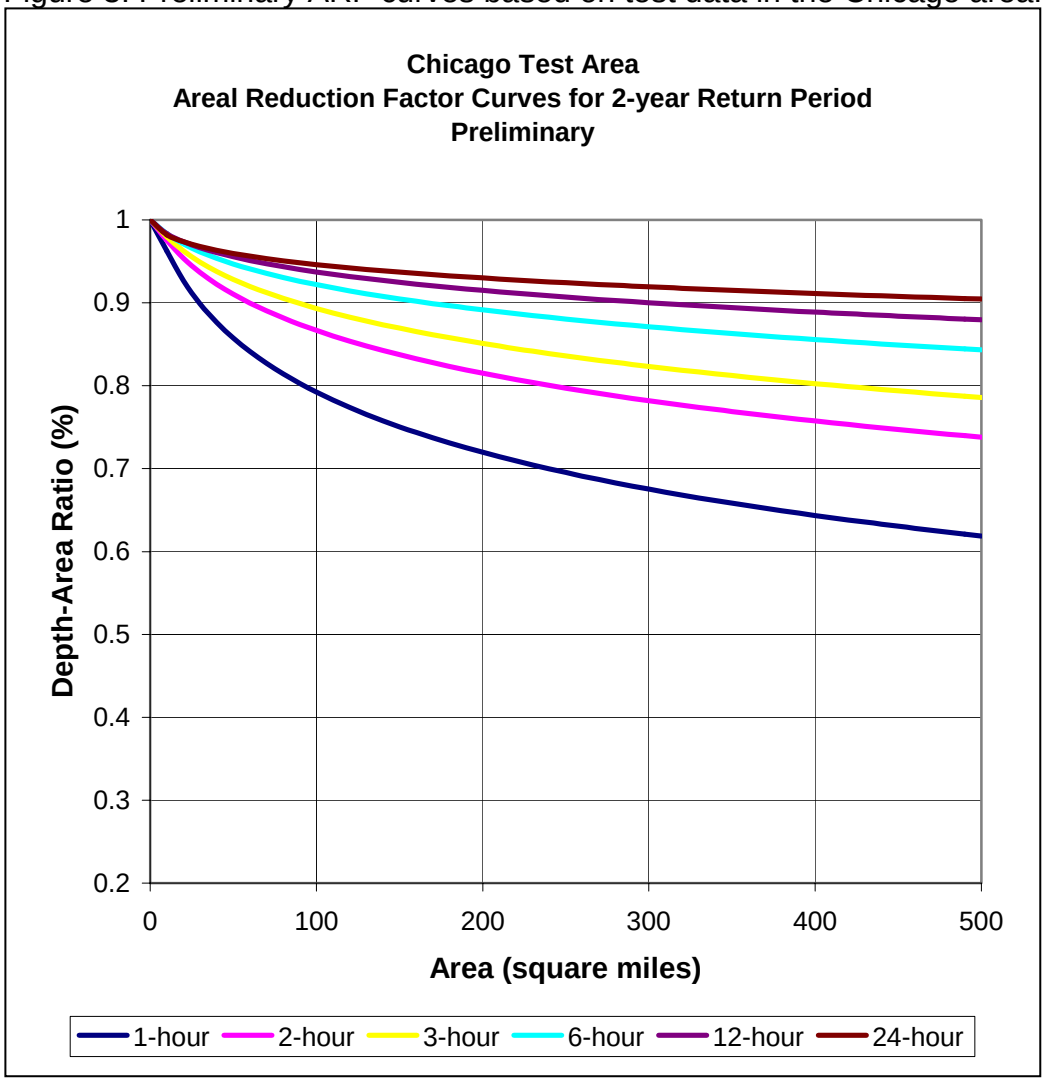
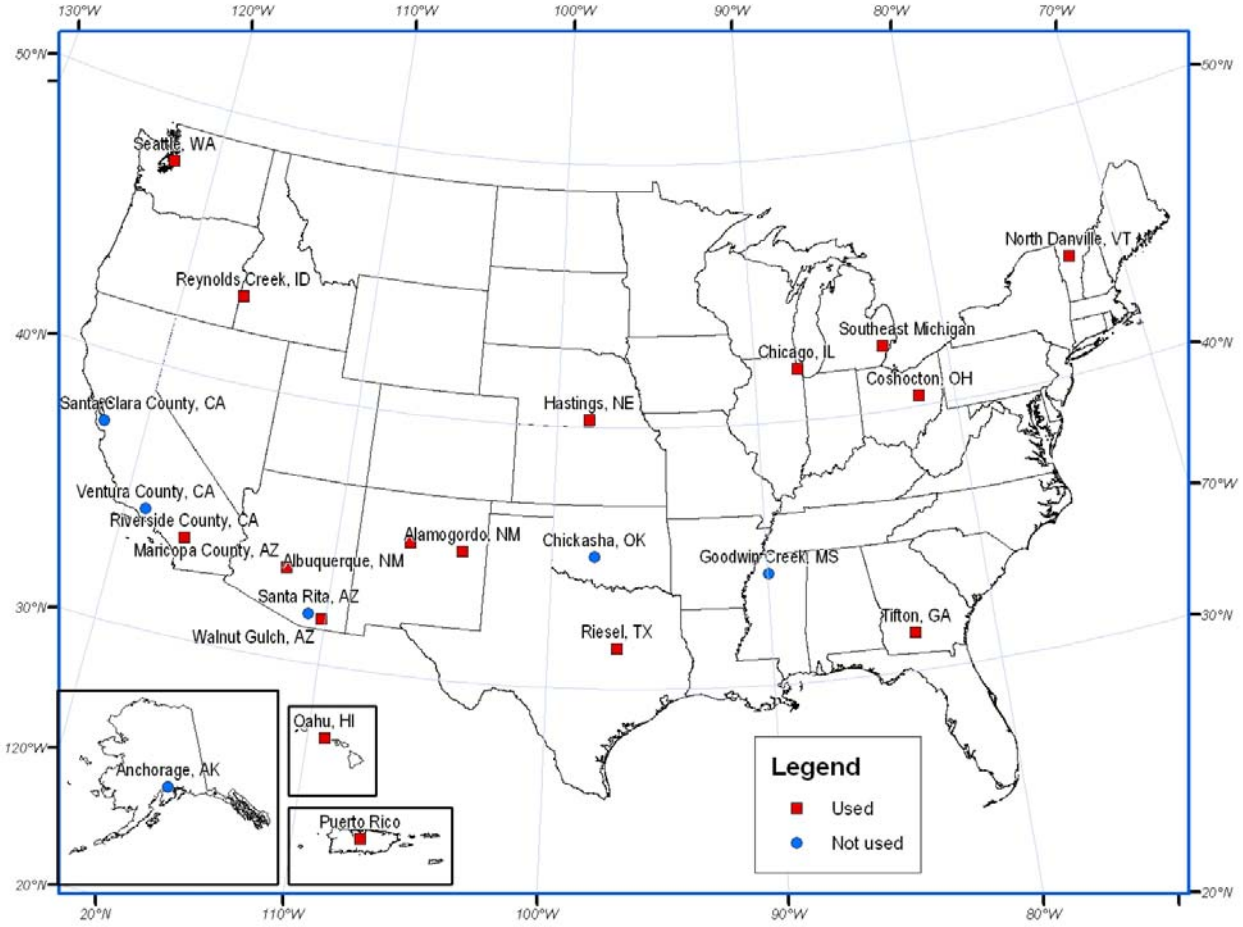


Figure 4: Map of ARF study areas



4. Issues

4.1 Recent and Upcoming Presentations

Past and future presentations by Geoff Bonnin, representing HDSC, include the following:

- "Temporal Distributions of Heavy Rainfall Associated with Updated Precipitation Frequency Estimates" at the Transportation Research Board Conference in Washington DC on January 15, 2004
- "Recent Updates to NOAA/NWS Rainfall Frequency Atlases" at the American Association of Geographers Annual Meeting in Philadelphia, PA on March 18, 2004
- "Recent Updates to NOAA/NWS Rainfall Frequency Atlases" at the Southeast Region meeting of the Association of State Dam Safety Officers in Norfolk, VA on April 19, 2004
- "Statistics of Recent Updates to NOAA/NWS Rainfall Frequency Atlases" at the American Society of Civil Engineers World Water and Environmental Resources Congress on June 28, 2004
- "Recent Updates to NOAA/NWS Rainfall Frequency Atlases" at the California Extreme Precipitation Symposium in Davis, CA on July 1, 2004
- An update of the Ohio River Basin and Surrounding States Precipitation Frequency Project progress at the 84th Meeting of the Ohio River Basin Commission on April 27, 2004

5. Projected Schedule and Remaining Tasks

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section.

Data Quality Control [Complete]
L-Moment Analysis/Frequency Distribution [Complete]
Spatial Interpolation [April 2004]
Precipitation Frequency Maps [May 2004]
Web Publication [May 2004]
Spatial Relations (Areal Reduction Factors) [June 2004]

5.1 Spatial Interpolation

Oregon State University using PRISM has completed (04/05/04) the final mean annual maxima grids for all durations. Next, HDSC will compute precipitation frequency estimates based on those grids and the selected parameterized probability distribution functions. We will spatially interpolate the precipitation frequency estimates using the

CRAB procedure and assess the mitigation of the bull's eyes. We will also compute the upper and lower 90% confidence intervals.

5.2 Precipitation Frequency Maps

Once the spatial interpolation is complete, final cartographic maps will be generated. We plan to produce all possible combinations of return frequencies (2-year through 1,000-year) and durations (5-minute through 60-day), which totals162 maps for each state or collection of states (roughly 9 separate geographic areas). This yields about 1,458 separate cartographic maps.

5.3 Documentation

Final documentation is currently being written for the Semiarid Project. During the next quarter, this text will be modified to reflect the Ohio Project.

5.4 Areal Reduction Factors (ARF)

Computations for the ARF curves will be completed in the next quarter for 15 areas. The resulting curves will be tested for differences to determine if a single set of ARF curves is applicable to the entire U.S. or whether curves vary by region.

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